THURSDAY, AUGUST 12, 1875

## THE SCIENCE COMMISSION REPORT ON THE ADVANCEMENT OF SCIENCE

SINCE our last week's issue two Reports of the above Commission have been issued, one of them, the Eighth and Final Report, dealing especially with the Advancement of Science.

We attach so much importance to this branch of the inquiry entrusted to the Commission, that we shall deal with the Eighth Report first; and as the Recommendations which the Commission make and the Considerations which have led up to them have long been anxiously looked for, we shall defer any remarks of our own this week, in order to give the Considerations and Recommendations *in extenso*. The following are the various branches into which the Report is divided :—

1. The Scientific Work carried on by Departments of the Government.
2. The Assistance at present given by the State towards the promotion of Scientific Research.
3. The Assistance which it is desirable the State should give towards that object.
4. The Central Organisation which is best calculated to enable the Government to determine its action in all questions affecting Science.

The general remarks made by the Commission on the evidence adduced on the first three heads are as follows :—

"The great advances in physical science which have been made in this country, and within this century, by such men as Dalton, Davy, and Faraday, without aid from the State; the existence of our numerous learned societies, and the devotion of some few rich individuals to the current work of science, at first sight appear to reduce the limits within which State aid to research is required in this country.

"But whilst we have reason to be proud of the contributions of some great Englishmen to our knowledge of the aws of nature, it must be admitted that at the present day scientific investigation is carried on abroad to an extent and with a completeness of organisation to which this country can offer no parallel. The work done in this country by private individuals, although of great value, is small when compared with that which is needed in the interests of science; and the efforts of the learned societies, not excepting the Royal Society, are directed to the discussion and publication of the scientific facts brought under their notice; these societies do not consider it any part of their corporate functions to undertake or conduct research.

"It will have been seen, from the extracts from the evidence, that amongst the witnesses who have advocated an increase of State assistance are some who have made great sacrifices in time and money in the cause of scientific research.

"But whatever may be the disposition of individuals to conduct researches at their own cost, the advancement of modern science requires investigations and observations extending over areas so large and periods so long that the means and lives of nations are alone commensurate with them.

"Hence the progress of scientific research must in a great degree depend upon the aid of Governments. As a nation we ought to take a share of the current scientific work of the world; much of this work has always been voluntarily undertaken by individuals, and it is not desirable that Government should supersede such efforts; but it is bound to assume that large portion of the national duty which individuals do not attempt to perform, or cannot satisfactorily accomplish.

"The following considerations have been suggested to us by the heads of evidence relating to (1) Laboratories, (2) Observatories, (3) Meteorology, (4) Tidal Observations, and (5) the Payment of scientific workers.

"1. The first condition of scientific investigation is that there should be collections, laboratories, and observatories accessible to qualified persons. The evidence has shown that at present, for certain branches, these do not exist or are incomplete.

"Moreover, there can be no doubt that the Government service should, to a great extent, contain within itself the means of carrying on investigations specially connected with the departments. Even having regard only to the current wants of the State, additional appliances are necessary.

"Three distinct ways have been suggested in which the State might assist in providing the aids to investigation which are required by private individuals. It has been proposed: first, that competent investigators should receive grants in money enabling them to provide themselves with means for conducting their researches; secondly, that laboratories, designed primarily for the service of the State, and those of Universities and other similar institutions receiving aid from the State, should be placed, under proper conditions, at the disposal of such inquirers; thirdly, that laboratories should be erected by the Government specially designed for the use of private investigators, though of course also available for the service of the State. Wherever the first of these methods can be conveniently and economically adopted, we are disposed to consider that it is the simplest and the best; but it must be remembered that for many researches apparatus of a costly but durable character are among the primary requisites; and that to provide these separately for each investigator would involve a large and unnecessary expenditure. It appears to us that the difficulty thus arising might be adequately met by the adoption of the second of the above suggestions. Our attention has, indeed, been called to the inconveniences which might arise from the admission of independent workers into University or State laboratories. But, notwithstanding this difficulty, we think the experiment is one which ought to be tried, and till it has been tried we should hesitate to recommend the erection by the State, for the especial use of private investigators, of laboratories which would certainly be costly, and might possibly be only imperfectly utilised.

"2. Upon a review of the whole of the evidence relating to the subject of Astronomical Physics, we are of opinion that an observatory for that branch of science should be established by the State. In the study of Solar Physics, continuity of the observations is of the greatest importance; and owing to our variable climate, continuous observations of the sun in this country are subject to peculiar difficulties which should be duly considered in the site for such an observatory. The neighbourhood of London is less favourable to physical observations than many other sites which might be found, and for this reason we should prefer that a physical observatory should be placed elsewhere than at Greenwich. On other grounds, also, we think that the Observatory for Astronomical Physics should be an institution entirely distinct from any of the national observatories for Mathematical Astronomy. The subject of Mathematical Astronomy is vast enough to occupy adequately the whole energies of a director, and it is especially important that Astronomical Physics should have the undivided attention of the head of an observatory, because its methods, which are of very recent invention, are as yet incompletely developed, and because, depending, as they do, on a continual comparison of celestial phenomena with the

results of experiments in the laboratory, they are entirely different from those of Mathematical Astronomy.

"Our opinion as to the desirability of such an institution is confirmed by the example of foreign nations; observatories for astronomical physics being already at work in various parts of Italy, and their immediate erection having been determined on at Berlin and at Paris:

"We venture to express the hope that similar institutions may before long be established in various parts of the British Empire. The regularity of the climatic conditions of India, and the possibility of obtaining there favourable stations at considerable heights, render it especially desirable that arrangements should be made for carrying on physical observations of the sun in that country.

"3. With respect to Meteorology we are of opinion that the operations of the Meteorological Office have been attended with great advantage to science and to the country. The subject of Meteorology is a very vast one, and any scheme for its proper cultivation or extension must comprise—(1) Arrangements for observing and registering meteorological facts; (2) Arrangements for the reduction, discussion, and publication of the observations; (3) Researches undertaken for the purpose of discovering the physical causes of the phenomena observed. The resources placed at the disposal of the Committee are inadequate to cover the whole of this wide field; and, having due regard to all the circumstances of the case, we believe that in selecting certain parts of it, as the objects of their special attention, they have been guided by a sound discretion.

"We are also disposed to consider that although, as we have already said, the Meteorological Committee occupies an anomalous position, no other form of organisation could advantageously have been adopted under the actual conditions. We think, however, that if, as we shall hereinafter recommend, a Ministry of Science should be established, the head of the Meteorological Office should be made responsible to the Minister. We fully concur with the opinion expressed by the witnesses that many branches of meteorology can only be effectually promoted by an organisation having the support of Government; and we would draw especial attention to the consideration that if meteorology is to take rank as a branch of terrestrial physics, the observations must be made at stations widely dispersed over all parts of the earth's surface, and those taken by observers of different nations must be so arranged as to be comparable with one another. It is obvious that the intervention of Government would greatly facilitate the attainment of both these objects.

"We are very unwilling that any scientific observations which can adequately be carried on by individuals or associations of individuals, should be undertaken by a department of the Government. So far as the local interests connected with climatic meteorology suffice to ensure due attention being paid to that branch of science, we should prefer to see it left mainly to scientific societies, any assistance the Government might afford being merely subsidiary. That useful results may be obtained by voluntary effort is evident from the work carried on under the direction of Mr. Glaisher, and from the case of the Scottish Meteorological Society, which has succeeded, with very narrow means, in organising a valuable system of observations on the meteorology of Scotland. It is, however, important that any grants for the promotion of meteorological observations in aid of voluntary efforts should be made on some systematic principle; and the attainment of this object would be furthered by making them subject to the control of a minister, who would be cognisant of all the facts relating to the expenditure of the Government upon meteorology.

"We may point out that the returns furnished by the Scottish Meteorological Society and Mr. Glaisher, are adopted by the Registrars General, and are recognised by Committees of Parliament in discussions affecting the public health, the supply of water, and other matters of the same kind. The value of observations undertaken, as in this case, by private individuals or voluntary associations, must vary from time to time, according to the efficiency of the persons principally concerned in their superintendence. We feel, therefore, that the question how far it is proper that such observations should receive official sanction, cannot be decided *a priori*, and must be left to the judgment of the responsible Minister for the time being.

"4. With regard to tidal observations, it will be seen that, in the opinion of the witnesses, these have not hitherto been conducted and reduced systematically. Considering the agencies which the Government can employ for the purpose of making these observations, the importance of providing proper superintendence for them, and of securing their reduction, we think it desirable that they should be carried on under Government control. The expense involved would chiefly consist in the establishment at proper points, and verification, of tide gauges, and in the reduction of the observations; these being entrusted to officers of Government already stationed at the ports and on the various coasts of the Empire.

"5. The witnesses have expressed themselves strongly as to the justice and policy of remuneration to investigators for their time and trouble, and the evidence also shows by implication how great must have been the sacrifices of those who without private fortune have hitherto devoted their great talents and their valuable time to such work without any remuneration whatever.

"It has hitherto been a rule in the granting of Government aid to scientific investigators, subject, so far as we have been able to ascertain, to but very few exceptions, that such aid should be limited to what was necessary to meet the expenditure actually incurred on instruments, materials, and assistance.

"To grants made under these conditions we think that considerable extension might be given.

"It is hardly necessary to assert the principle that when scientific work is undertaken at the request of the Government, the State is not only justified in paying, but is under obligation to pay for what is done on its behalf and for its service. But we desire to express our belief that there are many instances of unremunerative research in which the benefit conferred on the nation by those who have voluntarily engaged in it establishes a claim upon the State for compensation for their time and labour. Without such compensation much important work must remain unperformed, because it must be expected that many of the best men will not be in circumstances enabling them to devote long periods of time to unremunerated labour.

"It is a matter of course that State aid shall only be given to investigators whose capacity and industry have been placed beyond a reasonable doubt."

With regard to head IV., the Commissioners make the following general remarks:—

"The functions of the Government with regard to science may be summed up under the three following heads:—

"1. The treatment of the scientific questions incident to the business of the public departments.

"2. The direction of scientific instruction when given under the superintendence or control of the State.

"3. The consideration of all questions involving State aid towards the advancement of science, and of administrative questions arising out of such aid.

"It would be difficult to enumerate exhaustively all the various topics comprehended under these three heads, and it will be sufficient for the purpose of showing how wide

is the field of action of the State in regard to science, if we point out that under one or other of these heads are included all scientific questions affecting the army, the navy, the public health, the mercantile marine, public works, Government scientific establishments; the elementary instruction in science under the department of education in primary schools, in the science classes connected with the Science and Art Department, and in secondary schools so far as they are subject to Government control; the aid which is now given, or which it is desirable should be given, to universities and other bodies not directly connected with the State, for the middle and higher scientific instruction, and the control which the State either does or should exercise over them in virtue of such aid or otherwise; the appointments to all scientific offices in the gift of the Crown; grants to museums and their control by the State; aid to scientific expeditions of every kind; the establishment and direction of State laboratories and observatories; grants in aid of such laboratories not under State direction, and in aid of scientific research; and generally the allotment and control of public funds for similar purposes.

"The majority of the witnesses who have given evidence in relation to this branch of the inquiry, express dissatisfaction with the manner in which questions under the preceding heads are now determined, and either recommend the appointment of a special minister of science or of a minister of science and education.

"In most cases the witnesses recommend that such a minister should, in regard to science, be advised by a council. Others, however, are of opinion that the functions of such a council might be exercised by an administrative staff of the usual kind."

After adducing a mass of evidence with regard to this subject, the establishment of a Ministry and Council of Science, the Commission thus discusses it:—

"We have given careful consideration to this part of the Inquiry entrusted to us; and, in the course of our deliberations we have been led to attach much importance to the facts stated in the first part of our report, which show that the scientific work of the Government is at present carried on by many different departments.

"There is nothing to prevent analogous, if not actually identical, investigations being made in each of these, or to secure to one department an adequate knowledge of the results obtained, and the circumstances under which they were obtained, by another.

"Investigations admitted to be desirable, nay, practical questions, the solution of which is of the greatest importance to the public administration, are stated by the witnesses to be set aside because there is no recognised machinery for dealing with them; while, in other cases, investigations are conducted in such a manner as to involve a needless outlay of time and money, because they were originally planned without consultation with competent men of science.

"Passing to the question of the advancement of science, we have arrived at the conclusion that much has to be done which will require continuous efforts on the part of the administration unless we are content to fall behind other nations in the encouragement which we give to pure science, and, as a consequence, to incur the danger of losing our pre-eminence in regard to its applications.

"These considerations, together with others which have come before us in the course of our inquiry, have impressed upon us the conviction that the creation of a special Ministry dealing with science and with education is a necessity of the public service.

"This Ministry would be occupied (1) with all questions relating to scientific and general education, so far as these come under the notice of government; (2) with all questions incidental to the application of national funds for the advancement of science; and (3) with all scientific problems in the solution of which the other departments may desire external scientific advice or information. It would also be desirable that the department should receive information as to scientific investigation proposed by other branches of the Government, and record their progress and results.

"It is not within our province to express an opinion as to whether the subject of art should be included among the functions of this department; but we are satisfied that the Minister's attention should not be distracted by any immediate responsibility for affairs which have no connection with science, education, or art.

"We have considered whether the official staff of such a Ministry, however carefully selected, could be expected to deal satisfactorily with all the varied and complicated questions which would come before the department. We have given full weight to the objections which have been raised against the creation of a special council of science, and to the arguments in favour of referring scientific questions to learned societies, or to special committees appointed for the purpose, or to private individuals; but nevertheless we have arrived at the conclusion that an additional organisation is required through which the Minister of Science may obtain advice on questions involving scientific considerations, whether arising in his own department or referred to him by other departments of the Government.

"Such questions have from time to time been referred to the Council of the Royal Society, in which the best scientific knowledge of the time is fairly represented. The Committee chosen by that Council for the administration of the government grant of 1,000*l.* per annum in aid of scientific investigations has performed its work to the satisfaction of the Government, of men of science, and of the public. But if much more is to be done for the advancement of science than at present, and if the Departments in conducting their investigations are to have the benefit of the scientific advice which appears now to be frequently wanting, the Council of the Royal Society, chosen as it is for other purposes, could scarcely be expected to take upon itself functions which, it is true, are not different in kind, but which would involve increased responsibility and the expenditure of additional time and trouble. Moreover, amongst the questions on which the departments would require scientific advice, there would no doubt be many requiring a knowledge of the peculiar exigencies of the public service, which would be more readily understood and solved if some persons in direct relation with the departments formed a part of the body to be consulted. It is obviously of great importance that the council should be so constituted as to possess the confidence of the scientific world, and we believe that this confidence would be extended to a council composed of men of science selected by the Council of the Royal Society, together with representatives of other important scientific societies in the United Kingdom, and a certain number of persons nominated by the Government. We also believe that such a body would deserve and receive the confidence of the Government, and that it would be well qualified to administer grants for the promotion of pure science.

"The general opinion we have expressed as to the proper remuneration of scientific work would be applicable to the members of this Council, but the degree and manner in which the principle should be applied in this instance must be so largely dependent on circumstances that we cannot make any specific recommendation on the subject.

"It would be impossible that the Council should in all cases undertake the direct solution, by itself or even by sub-committees, of the problems submitted to it. In many instances, especially when experimental investigations are required, its duty would be accurately to define the problem to be solved, and to advise the Minister as

to the proper persons to be charged with the investigation.

"We are of opinion that the Council should not have the power of initiating investigations; it should, however, not be precluded, in exceptional cases, from offering to the Minister such suggestions as it may have occasion to make in the public interest.

"We believe that reference to such a council would be found to be so useful and convenient that it would become the usual course in cases of difficulty, but we would not diminish the responsibility or fetter the discretion of any Minister by making such reference obligatory, or by preventing a reference to committees or to individuals chosen by him, whenever that course might appear to him to be more desirable.

Finally the Report concludes with the following "Conclusions and Recommendations":—

"I. The assistance given by the State for the promotion of scientific research is inadequate, and it does not appear that the concession or refusal of assistance takes place upon sufficiently well-defined principles.

"II. More complete means are urgently required for scientific investigations in connection with certain Government departments; and physical as well as other Laboratories and apparatus for such investigations ought to be provided.

"III. Important classes of phenomena relating to Physical Meteorology, and to Terrestrial and Astronomical Physics, require observations of such a character that they cannot be advantageously carried on otherwise than under the direction of the Government.

"Institutions for the study of such phenomena should be maintained by the Government; and, in particular, an observatory should be founded specially devoted to Astronomical Physics, and an organisation should be established for the more complete observation of tidal phenomena and for the reduction of the observations.

"IV. We have stated in a previous Report that the national collections of Natural History are accessible to private investigators, and that it is desirable that they should be made still more useful for purposes of research than they are at present. We would now express the opinion that corresponding aid ought to be afforded to persons engaged in important physical and chemical investigations; and that whenever practicable such persons should be allowed access, under proper limitations, to such laboratories as may be established or aided by the State.

"V. It has been the practice to restrict grants of money made to private investigators for purposes of research to the expenditure actually incurred by them. We think that such grants might be considerably increased. We are also of opinion that the restriction to which we have referred, however desirable as a general rule, should not be maintained in all cases, but that, under certain circumstances and with proper safeguards, investigators should be remunerated for their time and labour.

"VI. The grant of 1,000*l.*, administered by the Royal Society, has contributed greatly to the promotion of research, and the amount of this grant may with advantage be considerably increased.

"In the case of researches which involve, and are of sufficient importance to deserve, exceptional expenditure, direct grants in addition to the annual grant made to the Royal Society, should be made in aid of the investigations.

"VII. The proper allocation of funds for research; the establishment and extension of laboratories and observatories; and, generally, the advancement of science and the promotion of scientific instruction as an essential part of public education, would be most effectually dealt with by a ministry of science and education. And we consider the creation of such a ministry to be of primary mportance.

"VIII. The various departments of the Government have from time to time referred scientific questions to the Council of the Royal Society for its advice; and we believe that the work of a minister of science, even if aided by a well-organised scientific staff, and also the work of the other departments, would be materially assisted if they were able to obtain, in all cases of exceptional importance or difficulty, the advice of a council representing the scientific knowledge of the nation.

"This council should represent the chief scientific bodies in the United Kingdom. With this view its composition need not differ very greatly from that of the present Government Grant Committee of the Royal Society. It might consist of men of science selected by the Council of the Royal Society, together with representatives of other important scientific societies, and a certain number of persons nominated by the Government. We think that the functions at present exercised by the Government Grant Committee might be advantageously transferred to the proposed Council."

## *HINRICHS' "PRINCIPLES OF CHEMISTRY"*

*The Principles of Chemistry and Molecular Mechanics.* By Dr. Gustavus Hinrichs, Professor of Physical Science in the State University of Iowa. (Davenport, Iowa, U.S.: Day, Egbert, and Fidlar, 1874.)

THIS work constitutes the second volume of a treatise on "The Principles of the Physical Sciences," and its main object is to present theoretical chemistry in its most modern aspect and to discuss its laws from a dynamical point of view. It is divided into two portions: "Molecular Statics," and "Molecular Dynamics." The former commences with an account of chemical atoms, it being premised that the conception of a chemical atom is the basis of the modern chemical theory. Although the author tells us that the chemical atom is a reality, while the philosophic atom is only a possibility, we have a little difficulty in accepting his definition of a chemical atom as "a very minute, relatively indivisible particle of matter." For it is surely unwise to retain a term so precise in its etymological significance if we admit its divisibility. We are told that "an atom of lead sulphide" can be divided into an atom of lead and an atom of sulphur; and further (p. 19), that "the molecule of gaseous compounds consists of one atom of the compound." But a molecule is defined as a "group of atoms" elsewhere, so that it would appear that a molecule is sometimes an atom, and an atom is sometimes a molecule, and such confusion of ideas must be most detrimental to the acquirement of exact knowledge by the student.

It is useless for us to protest against variations in the mode of writing formulæ, for such protestations have been made any time during the last ten years in vain; but we are quite justified in saying that such changes harass the student to an extent to which the authors of them can scarcely be aware. Why should NaCl be written $NaCl^{ide}$, and $KaNO_3$, $KaN^{ate}$, and so with all sulphates, oxalates, nitrates, and a host of other salts? And why, when the almost universal custom is to write sulphates as $MSO_4$, and nitrates as $MNO_3$, does our author write $MO_4S$ and $MO_3N$?

We are glad to notice the introduction of the recent surmises as to the absolute weight of atoms, although at present we believe that such ideas cannot be of much